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H2H HEM
H3P PDLR

(56) Documents Cited

GB 2271668 A	GB 2142780 A	EP 0380089 A2
US 4271450 A	US 4127835 A	US 3728654 A

(58) Field of Search
UK CL (Edition R) H1N NEG NEH NEJ NEK , H1P PAC PBA PMR , H2H HEM , H3P PDLR
INT CL^7 H01F 7/121 7/122 7/16 7/18 , H01H 47/22 47/32 51/22 51/27
Online: EPODOC, JAPIO, WPI

(54) Abstract Title
Pulse driven bistable electromagnetic actuator

(57) An electromagnetic actuator comprises a magnetically permeable outer shell 1 which houses a coil 2 within which is disposed an iron core 3 which can move axially. There are first and second permanent magnets 4A, 4B which are located in the shell 1 at either side of the iron core 3. They are axially aligned with each other with the same pole directed toward the iron core 3. A positive or negative pulse circuit 6, including a capacitor, is connected to the coil 2 and is arranged to drive the iron core 3 between end positions where it will be held in place by one of the permanent magnet latches 4A or 4B. The permanent magnets 4A, 4B may each include a magnetic guide ring 5 and the iron core 3 may be mounted in a non-magnetic guide sleeve. The actuator is intended to operate in an energy efficient manner without the use of spring means.

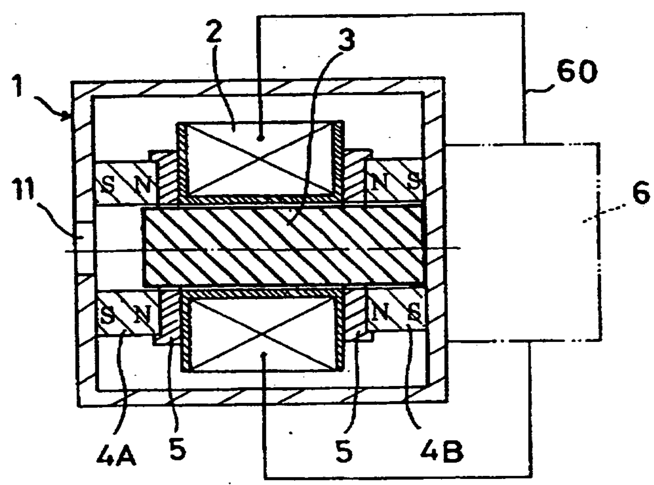
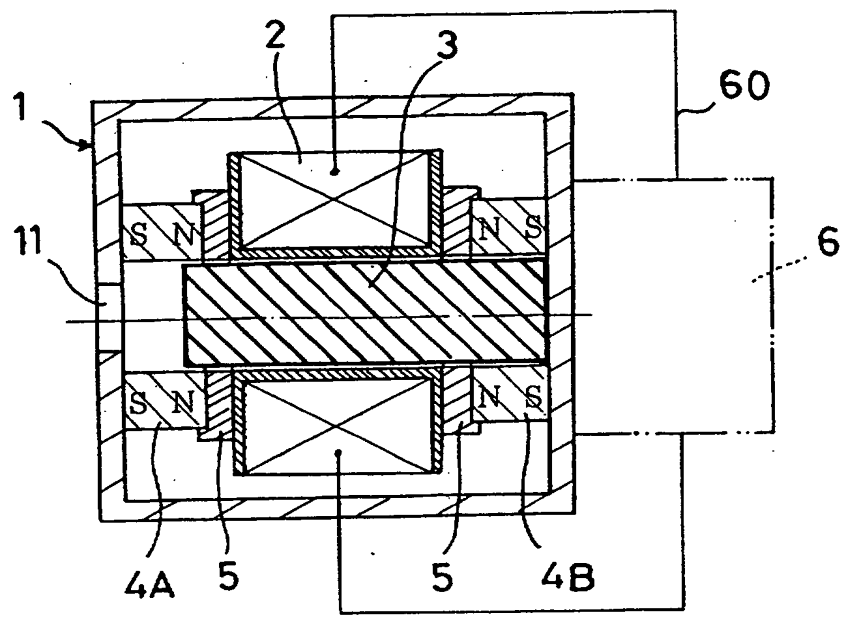
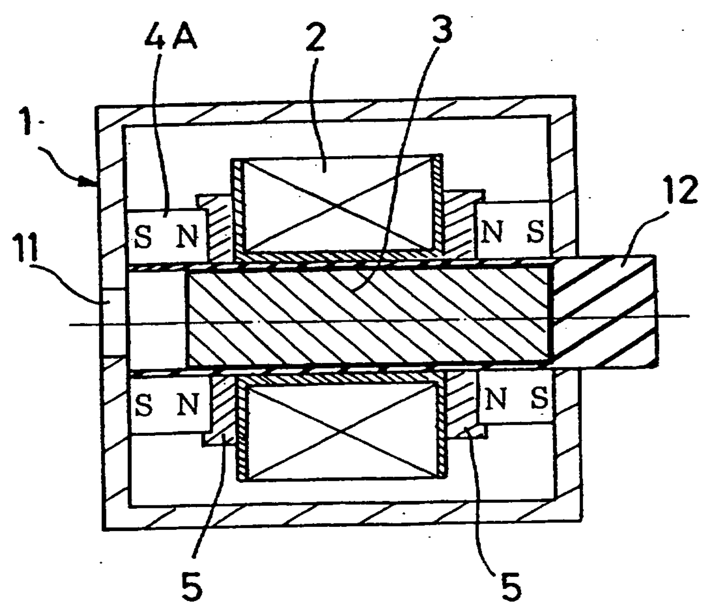


FIG.1

GB 2 357 375 A



F I G. 1



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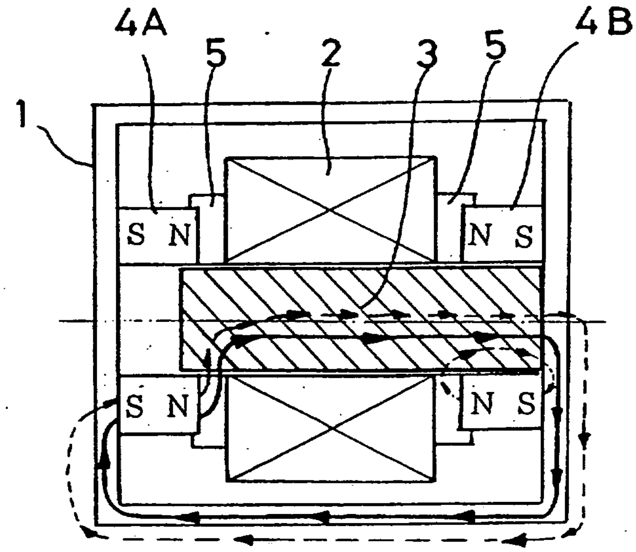


FIG. 3

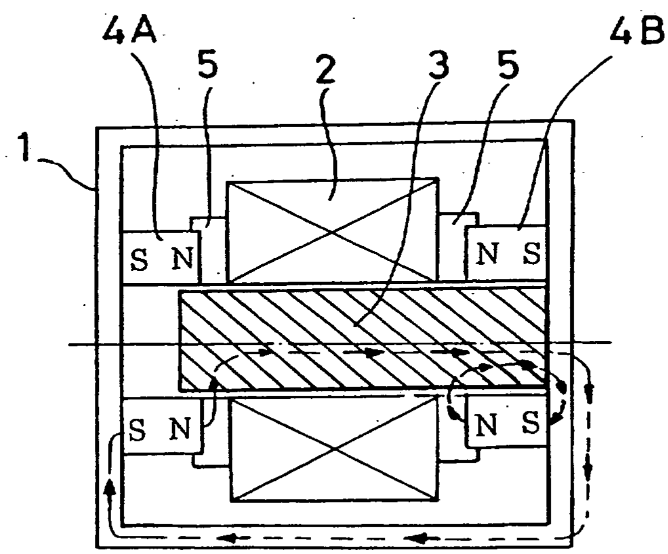
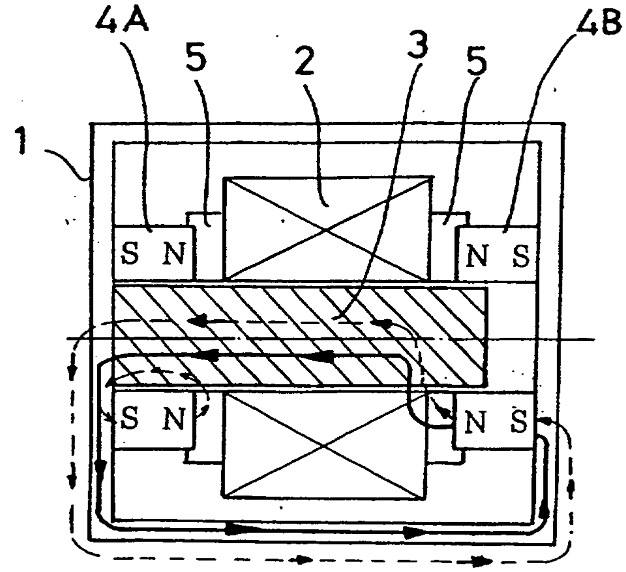
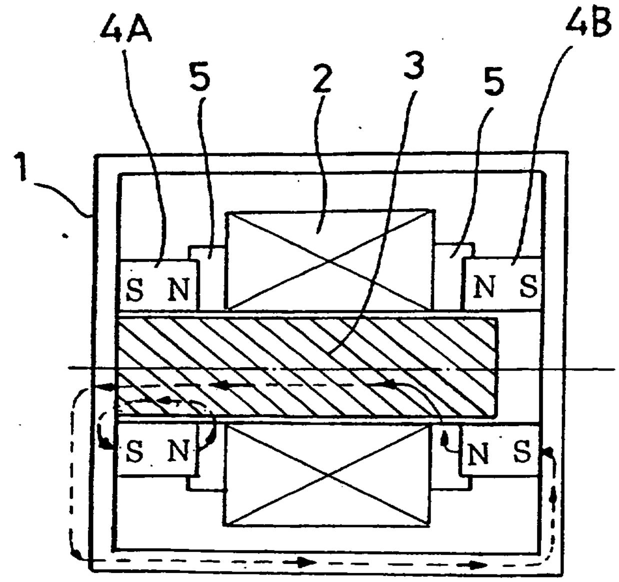


FIG. 4



F I G.5



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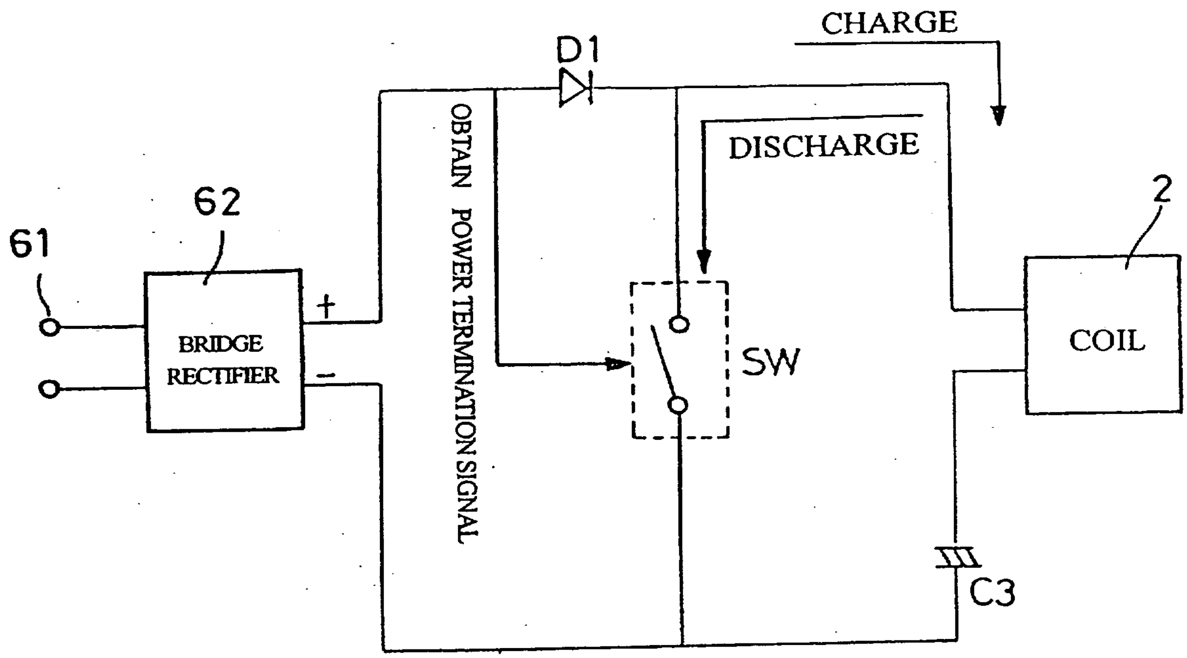
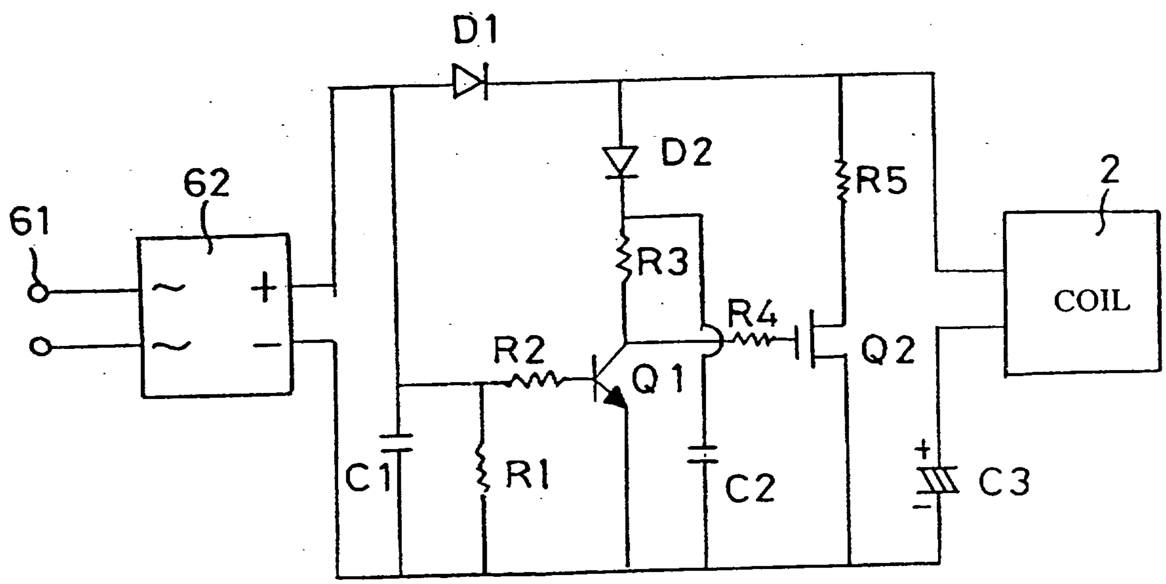


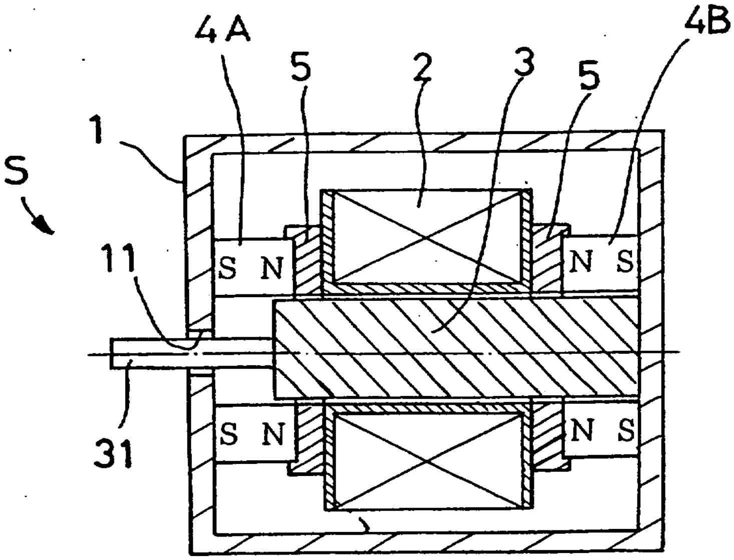
D1
CHARGE
DISCHARGE
OBTAIN POWER TERMINATION SIGNAL
61
62
BRIDGE RECTIFIER
+
−
SW
2
COIL
C3

F I G.7

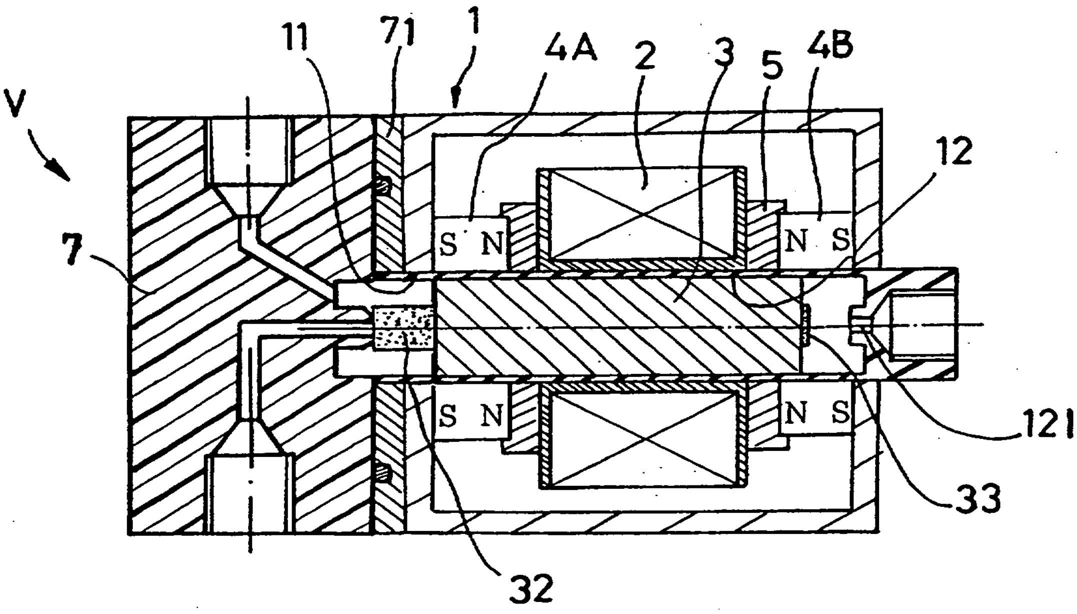


D1
D2
R5
61
62
~
+
~
−
R3
R4
R2
Q1
Q2
2
COIL
C1
R1
C2
+
C3
−

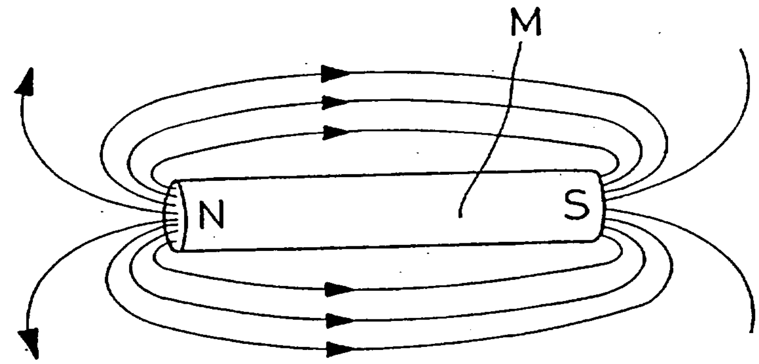
F I G. 8


4A
5
2
3
5
4B
1
S
11
S N
N S
31
S N
N S

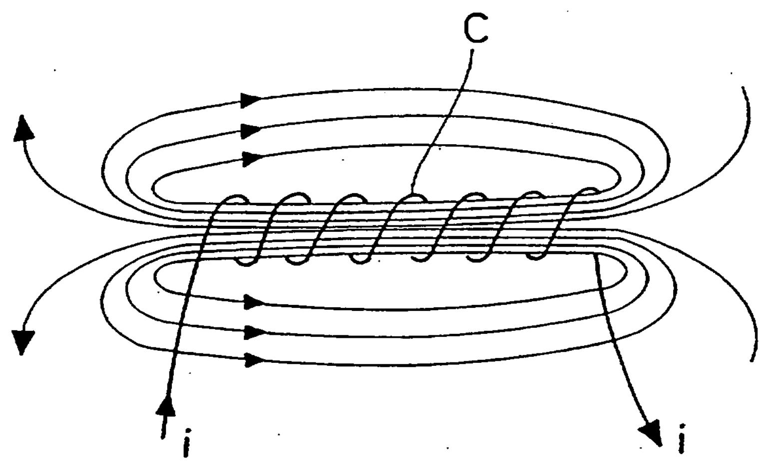
F I G. 9


11
71
1
4A
2
3
5
4B
V
12
7
S N
N S
S N
N S
121
33
32

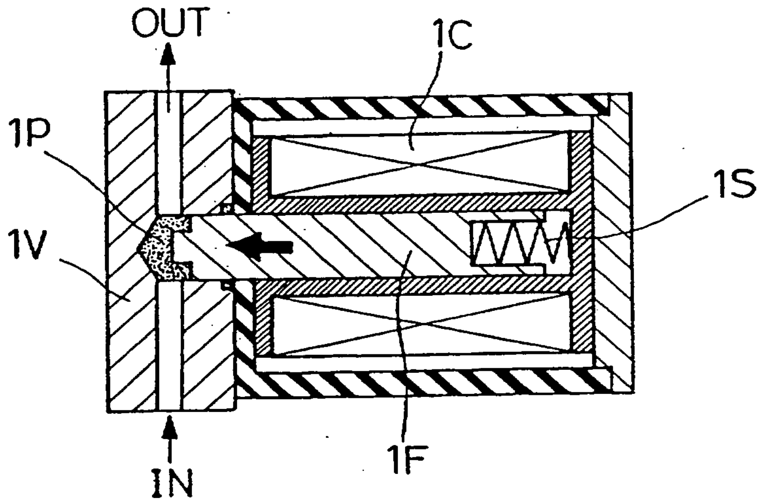
F I G. 10



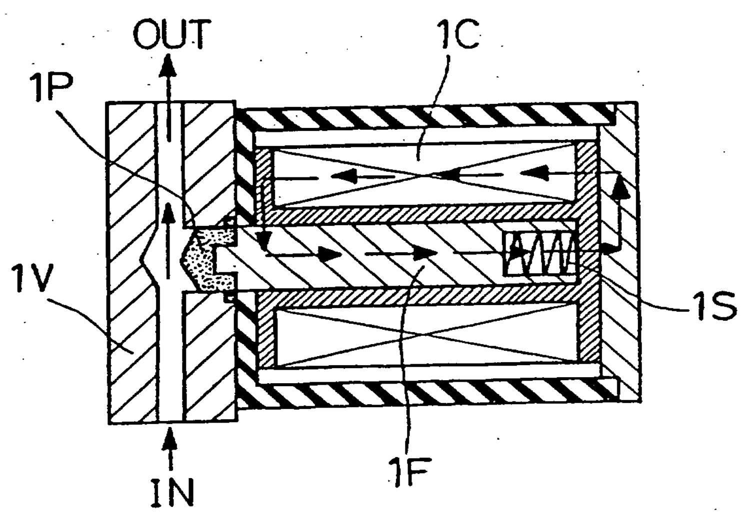
F I G.11



F I G.12



F I G.13



F I G.14

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Title:MAGNETIC POWER APPARATUS

BACKGROUND OF THE INVENTION

The present invention relates to a magnetic power apparatus for use in electromagnetic valves, solenoids, relays, etc., and more particularly to a power-saving, durable magnetic power apparatus, that can be controlled to change the direction of the magnetic path.

The concept of magnetic force is obtained from natural magnets. Natural magnets attract non-magnetized iron chips. The end of a natural magnet, which attracts non-magnetized iron chips, is a magnetic pole. Hans Christian Oersted, a scientist of Denmark, discovered the phenomenon of magnetic force in 1819. Hans Christian Oersted watches the occurrence of a deflection phenomenon when approaching a magnetic needle to an electrically conducted conductor. Later studies indicate the presence of magnetic lines of force in a magnetic field. Figure 11 shows the magnetic lines of force passé from N pole of the magnetic M through the air to C pole of the magnet M. Figure 12 shows magnetic lines of force pass from one end of a solenoid C through the air to the opposite end thereof after connection of electric current I to the solenoid C. It is apparent that the magnetic path is a closed path between N pole and S pole. In early 19 century, French scientist Ampere discovered same reason in the formation of the magnetic field of a magnet and the formation of the magnetic field of a solenoid, i.e., the formation of a magnetic field is due to the presence of an electric current on the inside or surface of the magnet. Nowadays, magnetic filed effect has been intensively used in

electromagnetic valves, solenoids, relays, etc. Figure 13 shows a conventional electromagnetic valve. When the coil 1C is energized, a magnetic force is produced to attract the iron core 1F, causing the valve port 1V to be opened. This design uses a spring 1S to keep the iron core 1F in (the closed) position. The spring force of the spring 1S offsets a part of the magnetic force of the coil 1C. This design wastes much electric energy, and the produces much heat during operation. Similar designs are seen in Taiwan Patent Publication Numbers 319343; 290615; 115728; 268552; 304570; 155433; 222448; 182896; 212501; 241854.

SUMMARY OF THE INVENTION

The present invention provides a magnetic power apparatus, which eliminates the aforesaid drawbacks. It is one object of the present invention to provide a magnetic power apparatus, which eliminates the use of spring means to hold the iron core in position. It is another object of the present invention to provide a magnetic power apparatus, which consumes less electric power. It is still another object of the present invention to provide a magnetic power apparatus, which is inexpensive to manufacture. It is still another object of the present invention to provide a magnetic power apparatus, which is practical for use in solenoids, magnetic valves, and relays. According to one aspect of the present invention, the magnetic power apparatus comprises an outer shell made of magnetically conductive metal, the outer shell having a through hole on one side wall thereof, an iron core axially movably disposed inside the outer shell, a coil positioned in the outer shell around the iron core and controlled to

move the iron core axially in the outer shell, a first permanent magnet and a second permanent magnet symmetrically mounted inside the outer shell and axially aligned at two opposite sides of the iron core with same pole aimed against each other, and a driving circuit disposed outside the outer shell and connected with a power output line thereof to the coil to charge a capacitor, the driving circuit outputting to the coil a positive impulse voltage when electrically connected, or a negative impulse voltage when electrically disconnected, causing the iron core to shift the iron core, and causing the first permanent magnet and the second permanent magnet to change magnetic path and to keep the iron core in shifted position. According to another aspect of the present invention, two magnetic guide rings are symmetrically provided between two distal ends of the coil and the first permanent magnet and second permanent magnet to enhance the magnetic force. According to still another aspect of the present invention, a non-magnetically conductive sleeve is mounted inside the outer shell to guide movement of said iron core.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a sectional view of a magnetic power apparatus according to a first embodiment of the present invention, showing the iron core shifted rightwards.

Figure 2 is a sectional view of a magnetic power apparatus according to a second embodiment of the present invention, showing the iron core shifted rightwards.

Figure 3 illustrates the status of the magnetic lines of force of the present invention after provision of a positive impulse voltage from the driving circuit.

Figure 4 illustrates the status of the magnetic lines of force of the present invention after rightward movement of the iron core and power off of the coil.

Figure 5 illustrates the status of the magnetic lines of force of the present invention after provision of a negative impulse voltage from the driving circuit.

Figure 6 illustrates the status of the magnetic lines of force of the present invention after leftward movement of the iron core and power off of the coil.

Figure 7 is a circuit block diagram of the present invention, showing the arrangement of the driving circuit.

Figure 8 is a detailed circuit diagram of the driving circuit according to the present invention.

Figure 9 shows an application example of the present invention for use as a solenoid.

Figure 10 shows another application example of the present invention used in an electromagnetic valve.

Figure 11 illustrates the distribution of magnetic lines of force of a regular permanent magnet.

Figure 12 illustrates the distribution of magnetic lines of force of a regular solenoid.

Figure 13 is a sectional view of a conventional electromagnetic valve when disenergized.

Figure 14 is similar to Figure 13 but showing the electromagnetic valve energized.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to Figure 1, the present invention comprises an outer shell 1, which can have a cylindrical, rectangular, or any of a variety of shapes, an iron core 3 axially movably disposed inside the outer shell 1, and a coil 2 positioned in the outer shell 1 around the iron core 3. The outer shell 1 is made of magnetically conductive metal, having a through hole 11 through one side thereof in axial alignment with the iron core 3. A first permanent magnet 4A and a second permanent magnet 4B are symmetrically mounted inside the outer shell 1, and axially aligned at two opposite sides of the iron core 3 with same pole aimed against each other. A driving circuit 6 is disposed outside the outer shell 1, having a power output line 60 connected to the coil 2. When power supply is connected, the driving circuit 6 outputs a positive impulse voltage, and stores electric energy in a capacitor. When power supply is off, the driving circuit 6 outputs a negative impulse voltage. The transient positive or negative impulse voltage (about 0.01 second) causes the coil 2 to change magnetization direction, and to produce an active force, causing the

iron core 3 to move. The operation of the driving circuit 6 also forces the first permanent magnet 4A and the second permanent magnet 4B to change magnetic path, causing the iron core 3 to be normally maintained in a particular position. Magnetic guide rings 5 are symmetrically provided between the coil 2 and the permanent magnets 4A and 4B to enhance the effect of magnetic force.

Figure 2 shows an alternate form of the present invention. According to this embodiment, a sleeve 12 is mounted inside the outer shell 1 around the iron core 3 to guide axial movement of the iron core 3. The sleeve 12 is made of non-magnetically conductive material, for example, copper. The use of the sleeve 12 does not affect the effect of the magnetic force of the coil 2 and the permanent magnets 4A and 4B.

Figure 3 shows the status of the magnetic lines of force of the present invention after provision of a positive impulse voltage from the driving circuit. When a magnetic force is produced greater than the first permanent magnet 4A and the second permanent magnet 4B after provision of a proper voltage to the coil 2, the paths of magnetic force (the imaginary line) of the first permanent magnet 4A and the second permanent magnet 4B are changed to the direction of the magnetic force (the real line) of the coil 2, thereby causing the iron core 3 to be moved rightwards by the magnetic force of the coil and the magnetic force of the permanent magnets. After rightward movement of the iron core 3, the coil 2 is disenergized, and the enclosed magnetic path of each permanent

magnets 4A or 4B passes from the respective N pole through the corresponding magnetic guide ring 5 to the respective S pole, keeping the iron core 3 in the right side position (see Figure 4).

Referring to Figure 5, when a negative impulse voltage, which is greater than the magnetic force of the permanent magnets 4A and 4B, is given from the driving circuit 6 to the coil 2, the paths of magnetic force (the imaginary line) of the first permanent magnet 4A and the second permanent magnet 4B are changed to the direction of the magnetic force (the real line) of the coil 2, thereby causing the iron core 3 to be moved leftwards by the magnetic force of the coil and the magnetic force of the permanent magnets. After leftward movement of the iron core 3, the coil 2 is disenergized, and the enclosed magnetic path of each permanent magnets 4A or 4B passes from the respective N pole through the corresponding magnetic guide ring 5 to the respective S pole, keeping the iron core 3 in the left side position.

As indicated above, the magnetic force of the coil 2 causes the iron core 3 to change its position, and simultaneously causes the first permanent magnet 4A and the second permanent magnet 4B to change their magnetic path, and the iron core 3 can be kept in position by means of the effect of the magnetic force of the permanent magnets 4A and 4B after disconnection of electricity from the coil 2. Therefore, the invention eliminates the use of spring means to keep the iron core in position (in prior art designs, the use of spring means greatly reduces the effect of forward magnetic force from the coil,

i.e., much magnetic force must be provided from the coil to move the iron core and to conquer the spring force from spring means). Further, because an impulse voltage (about 0.01 second) is sufficient to causes the iron core to change its position, it is not necessary to continuously supply electric current to the coil. Therefore, the present invention saves much electric energy, prevents a short-circuit or overheat, and prolongs the service life of the magnetic power device.

Referring to Figures 7 and 8 and Figures 1 and 3 again, the power output line 60 of the driving circuit 6 is connected to the coil 2. The driving circuit 6 comprises a bridge rectifier 62, and a plug 61. After connection of the plug 61 to power source, AC or DC power source is rectified by the bridge rectifier 62 into impulse DC current or directional DC current, which is then transmitted through a diode Dl to charge a capacitor C3 via the coil 2 and at the same time to energize the coil 2, thereby causing the iron core 3 to be shifted to the right side (see Figure 3). When power source is continuously supplied, charging current is stopped after the capacitor C3 has been charged to the saturated status. Thereafter, the charging circuit simply compensates leakage current, keeping the capacitor C3 at a constant voltage. When power source is off, the discharging circuit receives a signal to drive a switch SW, causing the capacitor C3 to discharge a negative impulse voltage to the coil 2, and therefore the iron core 3 is moved leftwards by the magnetic force of the coil 2.

Referring to Figure 8 again, the bridge rectifier 62 of the driving circuit 6 rectifies AC or DC power source into impulse DC current or directional DC current for charging the capacitor C3 through the coil 2. When AC power source is off, the discharging circuit obtains a signal to switch on the switch SW, which is comprised of a transistor Q2, thereby causing the capacitor C3 to provide a negative impulse voltage to the coil 2. The resistors R1 and R2, the capacitor C1 and the transistor Q1 keep the transistor Q2 of the switch SW off when the charging circuit works. Further, the diode D2, the capacitor C2 and the resistors R3 and R4 enable the capacitor C3 to discharge the voltage completely. The resistor R5 limits discharging current.

Referring to Figure 9, an actuating rod 31 is connected to the iron core 3 and extended out of the outer shell 1 through the through hole 11, forming with the magnetic power apparatus a solenoid S. The solenoid S can then be used with contact switch means, forming a relay.

Figure 10 shows an application example of the embodiment shown in Figure 1. A valve block 7 is disposed in front of the outer shell 1, and two rubber gaskets 32 and 33 are respectively provided at the front and rear ends of the iron core 3. When the iron core 3 is moved in the sleeve 12, the operation of an electromagnetic valve V is achieved. A relief port 121 is formed on the rear end of the sleeve 12 for exhaust of return gas. The front end of the sleeve 12 extends out of the through hole 11 on the outer shell 1, and is coupled to the rubber gasket 71 at the valve block 7, preventing direct contact of the

permanent magnets 4A and 4B with the fluid passing through the valve block 7.

It is to be understood that the drawings are designed for purposes of illustration only, and are not intended for use as a definition of the limits and scope of the invention disclosed.

What the invention claimed is:

1. A magnetic power apparatus comprising an outer shell, an iron core axially movably disposed inside said outer shell, and a coil positioned in said outer shell around said iron core and controlled to move said iron core axially in said outer shell, wherein said outer shell is made of magnetically conductive metal, having a through hole through one side thereof in axial alignment with said iron core; a first permanent magnet and a second permanent magnet are symmetrically mounted inside said outer shell, and axially aligned at two opposite sides of said iron core with same pole aimed against each other; a driving circuit is disposed outside said outer shell, and connected with a power output line thereof to said coil to charge a capacitor thereof, said driving circuit outputting to said coil a positive impulse voltage when electrically connected, or a negative impulse voltage when electrically disconnected, causing said iron core to shift said iron core, and causing said first permanent magnet and said second permanent magnet to change magnetic path and to keep said iron core in shifted position.

2. The magnetic power apparatus of claim 1 further comprising two magnetic guide rings symmetrically provided between two distal ends of said coil and said first permanent magnet and second permanent magnet.

3. The magnetic power apparatus of claim 1 further comprising a non-magnetically conductive sleeve mounted inside said outer shell to guide movement of said iron core.

4. A magnetic power apparatus substantially as herein described with reference to and as illustrated in the accompanying drawings.

The Patent Office 12

INVESTOR IN PEOPLE

Application No: GB 9929829.1
Claims searched: 1 - 4

Examiner: John Watt
Date of search: 14 March 2000

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

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Int Cl (Ed.7): H01F 7/121, 7/122, 7/16, 7/18; H01H 47/22, 47/32, 51/22, 51/27

Other: Online: EPODOC, JAPIO, WPI

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
Y	GB 2271668 A	(WESTINGHOUSE ELECTRIC) see fig.2 and page 4, line 22 - page 5, line 36	1 - 3
Y	GB 2142780 A	(MESSERSCHMITT) see figs.1 & 2 and page 1, lines 5 - 7	1 - 3
Y	EP0380089 A2	(SDS-RELAIS) see figs.1 - 10 and col.1, lines 7 - 13	1 - 3
Y	US 4271450	(MATSUSHITA) see figs.1 - 12 and col.2, lines 8 - 15	1 - 3
Y	US 4127835	(DYNEX / RIVETT) see figs.1 - 7 and col.4, lines 36 - 50	1 - 3
Y	US 3728654	(HOSHIDENKI-SEIZO) see figs.1 - 3C and col.1, lines 36 - 58	1 - 3

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